Bayesian networks and linear logic quantitative semantics

Topic
probabilistic programming languages, bayesian inference, linear logic, denotational semantics.

City and country:
mainly Paris - France (IRIF), possibly a short visit to Boston - USA (Boston University)

Team or project in the lab:
IRIF (participation to the ANR project PPS)

Name and mail of the advisor:
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. General presentation of the topic (roughly 5 to 10 lines)
This internship will focus on topics sitting in between bayesian inference and linear logic. The former is a very active research subarea in machine learning, studying efficient algorithms for statistical inference (see e.g. chapter 1 of [1]). The latter allows for denotational models of lambda-calculus approximating programs as polynomials (see e.g. [3,4]). The general goal of the internship is to transfer technologies from one side to the other, taking advantages and the algebraic structures that the two fields share.

. Objective of the internship (roughly 10 to 20 lines)
Bayesian inference aims at providing efficient algorithms for updating a probabilistic distribution according to some observations (e.g. updating the probability of having a cancer, knowing that the patient is smoking). One crucial technique is to factor polynomials into products following some diagrammatical representations of probabilistic distributions, such as bayesian networks and factor graphs (see chapter 8 of [1]).

Linear logic splits the classical connectives into two families, multiplicatives and additives [2]. This allows for quantitative denotational semantics in which functional programs are approximated by polynomials, giving a faithful description of various computational behaviours, such as the execution time or the probability of getting a result when applied to random data (see e.g. [3,4]). In practice, computing these polynomials is unfeasible even for small programs.

The goal of the internship is to adapt some of the bayesian inference algorithms in order to get more realistic computations, linking bayesian networks with control flow graphs.

. Bibliographic references

. Expected ability of the student
Expertise in two or more of the following topics: functional programming, lambda-calculus, linear logic, denotational semantics, bayesian inference, probabilistic graphical models, statistical machine learning, statistics